ICS 321 Fall 2010

Other Data Models : Unstructured, Graph, Key-Value Pairs

Asst. Prof. Lipyeow Lim

Information & Computer Science Department

University of Hawaii at Manoa

Outline

Unstructured Data and Inverted Indexes

Web Search Engines

RDF & Linking Open Data

Big Table, CouchDB, & Cassandra

Unstructured Data

- What are some examples of unstructured data?
- How do we model unstructured data ?
- How do we query unstructured data ?
- How do we process queries on unstructured data ?
- How do we index unstructured data ?

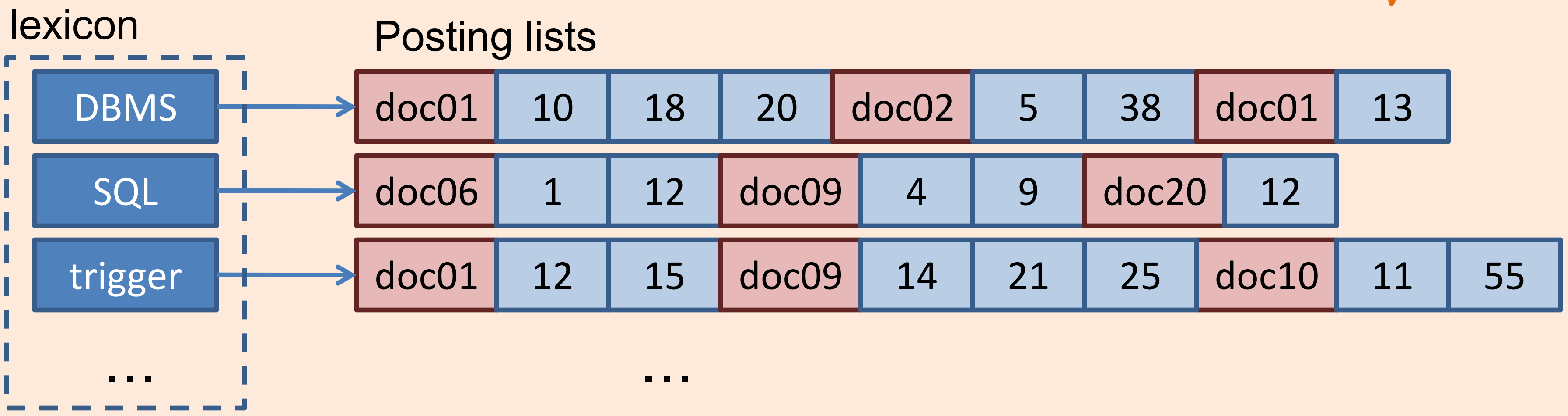
Unstructured Text Data

- Field of "Information Retrieval"
- Data Model
  - Collection of documents
  - Each document is a bag of words (aka terms)
- Query Model
  - Keyword + Boolean Combinations
  - Eg. DBMS and SQL and tutorial
- Details:
  - Not all words are equal. "Stop words" (eg. "the", "a", "his" ...) are ignored.
  - Stemming : convert words to their basic form. Eg. "Surfing", "surfed" becomes "surf"

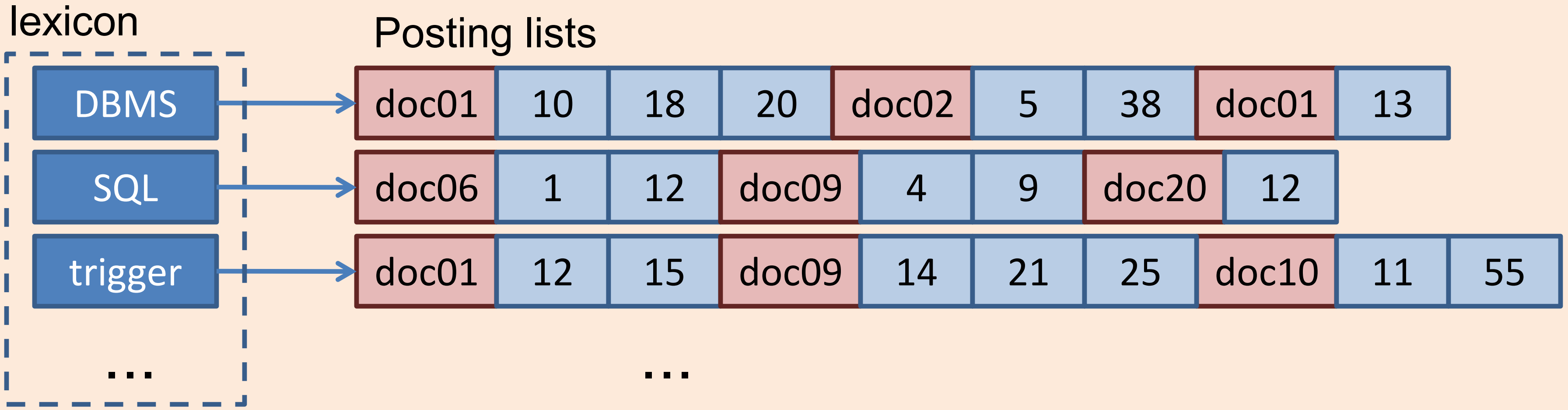
Inverted Indexes

- Recall: an index is a mapping of search key to data entries
  - What is the search key ?
  - What is the data entry ?
- Inverted Index:
  - For each term store a list of postings
  - A posting consists of <docid,position> pairs

What is the data in an inverted index sorted on ?


lexicon
Posting lists
DBMS
doc01 | 10 | 18 | 20 | doc02 | 5 | 38 | doc01 | 13
SQL
doc06 | 1 | 12 | doc09 | 4 | 9 | doc20 | 12
trigger
doc01 | 12 | 15 | doc09 | 14 | 21 | 25 | doc10 | 11 | 55
…
…

Lookups using Inverted Indexes

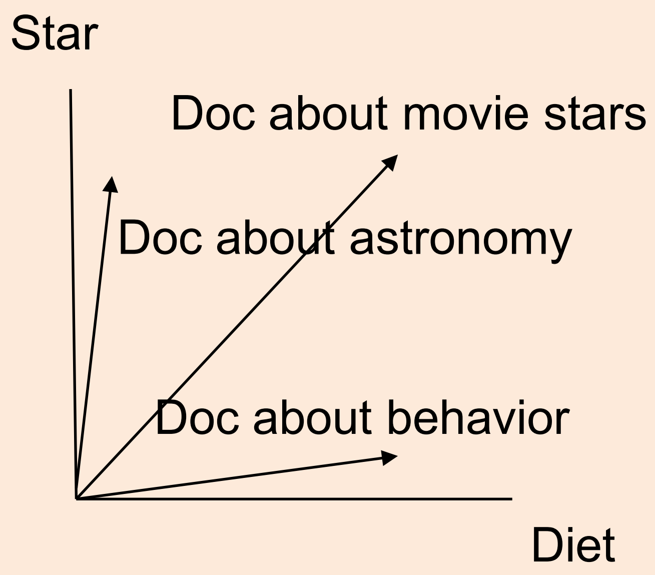


lexicon
Posting lists
DBMS
SQL
trigger
…
doc01 10 18 20 doc02 5 38 doc01 13
doc06 1 12 doc09 4 9 doc20 12
doc01 12 15 doc09 14 21 25 doc10 11 55
…

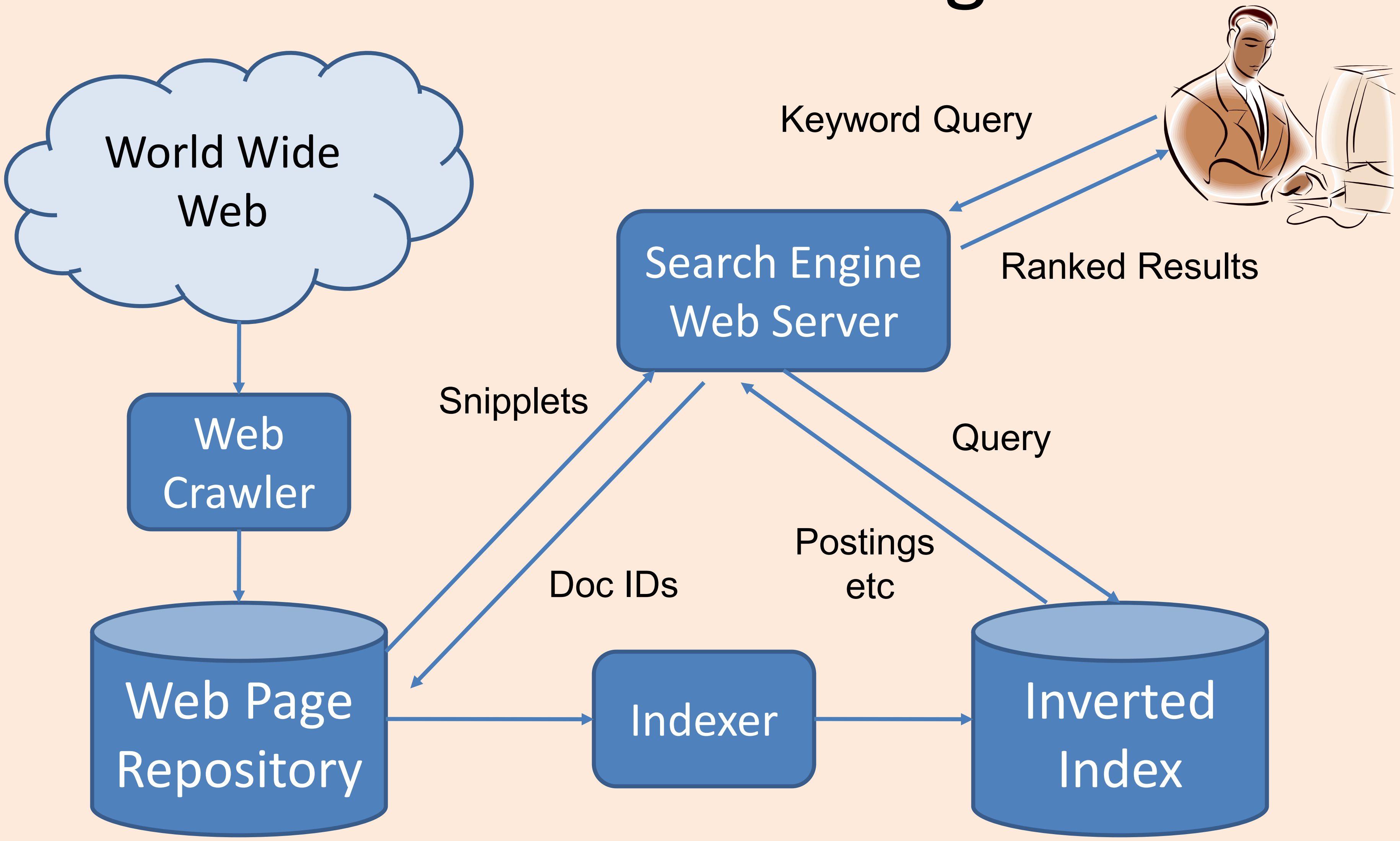
- Given a single keyword query "k" (eg. SQL)
  - Find k in the lexicon
  - Retrieve the posting list for k
  - Scan posting list for document IDs [and positions]
- What if the query is "k1 and k2" ?
  - Retrieve document IDs for k1 and k2
  - Perform intersection

Too Many Matching Documents

- Rank the results by "relevance"!
- Vector-Space Model
  - Documents are vectors in hi-dimensional space
  - Each dimension in the vector represents a term
  - Queries are represented as vectors similarly
  - Vector distance (dot product) between query vector and document vector gives ranking criteria
  - Weights can be used to tweak relevance
- PageRank (later)

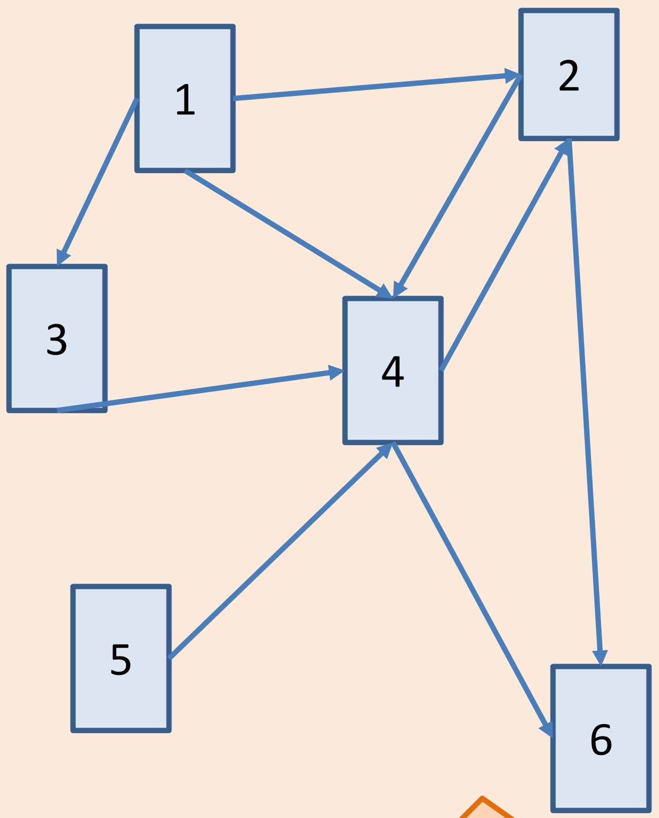


Internet Search Engines



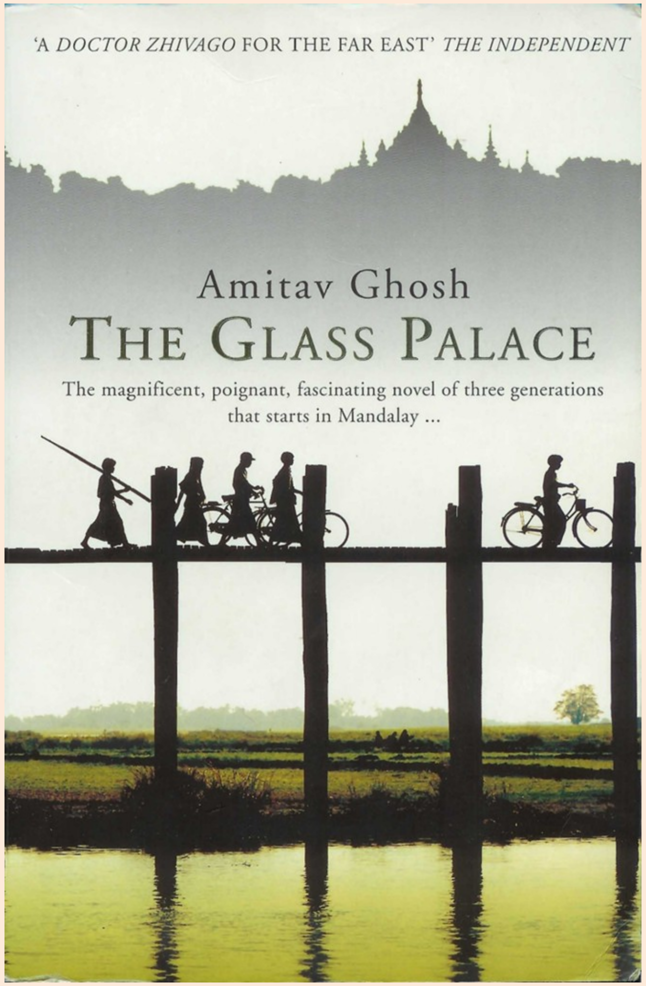
Ranking Web Pages

- Google's PageRank
  - Links in web pages provide clues to how important a webpage is.
- Take a random walk
  - Start at some webpage p
  - Randomly pick one of the links and go to that webpage
  - Repeat for all eternity
- The number of times the walker visits a page is an indication of how important the page is.



Vertices represent web pages.
Edges represent web links.

Resource Description Framework (RDF)

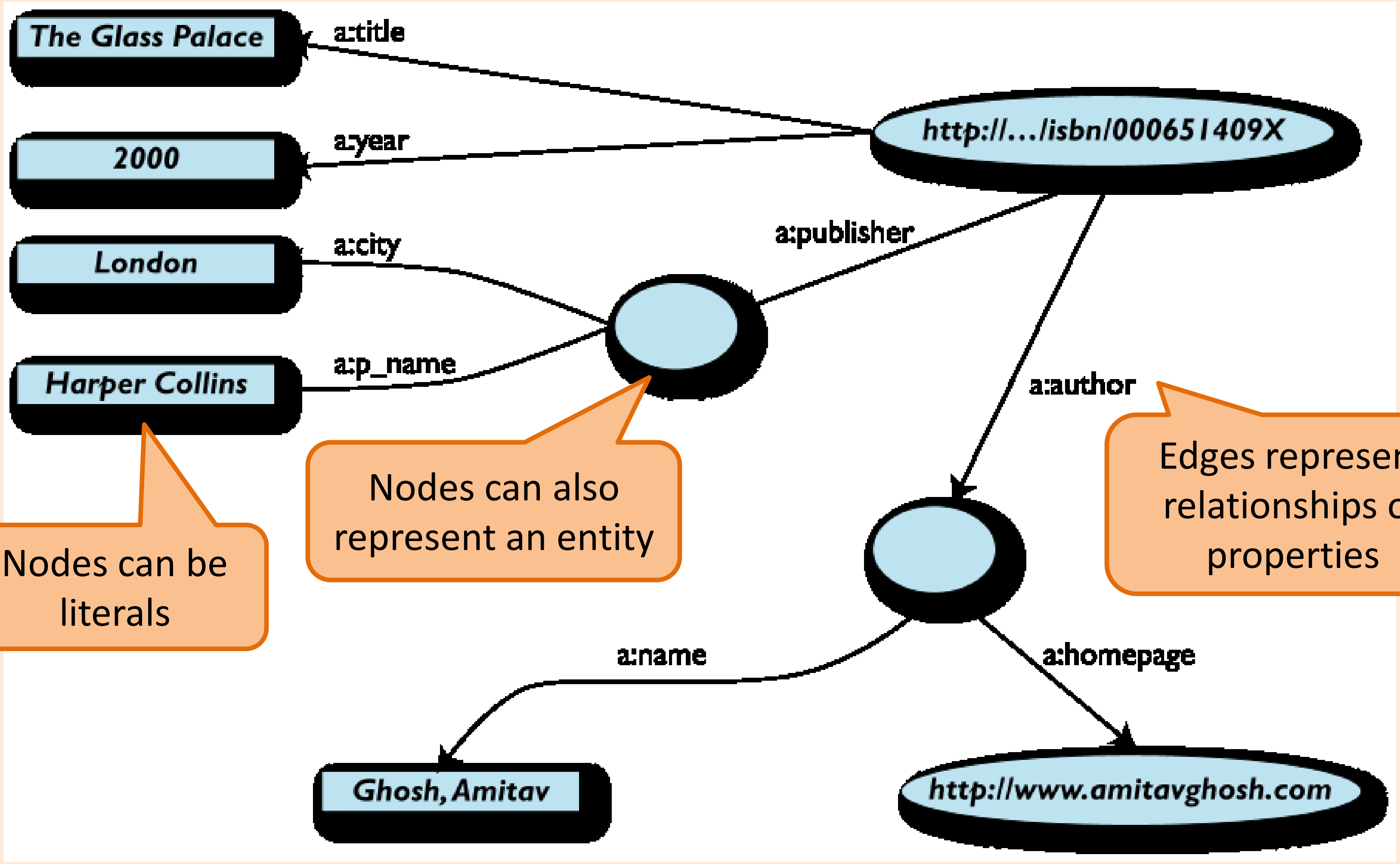

'A DOCTOR ZHIVAGO FOR THE FAR EAST' THE INDEPENDENT
Amitav Ghosh
THE GLASS PALACE
The magnificent, poignant, fascinating novel of three generations that starts in Mandalay ...

ID	Author	Title	Publisher	Year
Isbn0-00-651409-X	Id_xyz	The glass palace	Id_qpr	2000

ID	Name	Homepage
Id_xyz	Ghosh, Amitav	http://www.amitavghosh.com

ID	Publisher Name	City
Id_qpr	Ghosh, Amitav	London

RDF Graph Data Model



Nodes can be literals

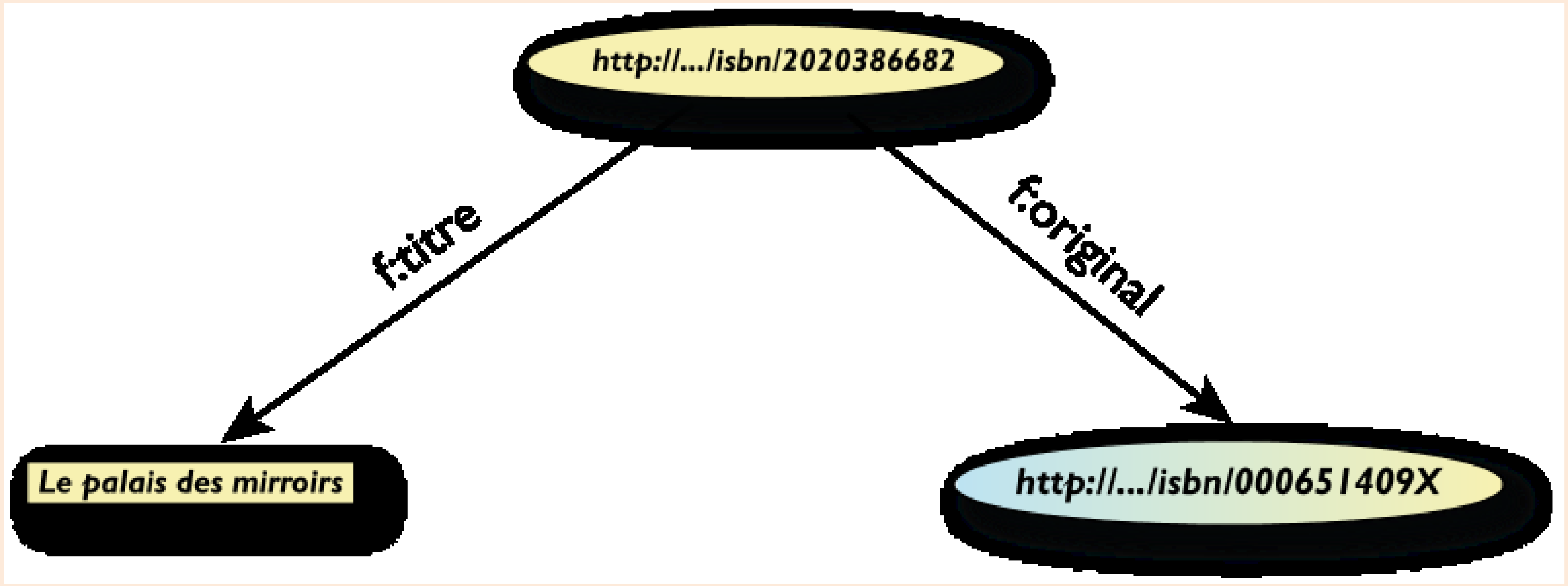
Nodes can also represent an entity

Edges represent relationships or properties

More formally

- An RDF graph consists of a set of RDF triples
- An RDF triple (s,p,o)
  - “s”, “p” are URI-s, ie, resources on the Web;
  - “o” is a URI or a literal
  - “s”, “p”, and “o” stand for “subject”, “property” (aka “predicate”), and “object”
  - here is the complete triple: (<http://...isbn...6682>, <http://..//original>, <http://...isbn...409X>)
- RDF is a general model for such triples
- RDF can be serialized to machine readable formats:
  - RDF/XML, Turtle, N3 etc

RDF/XML



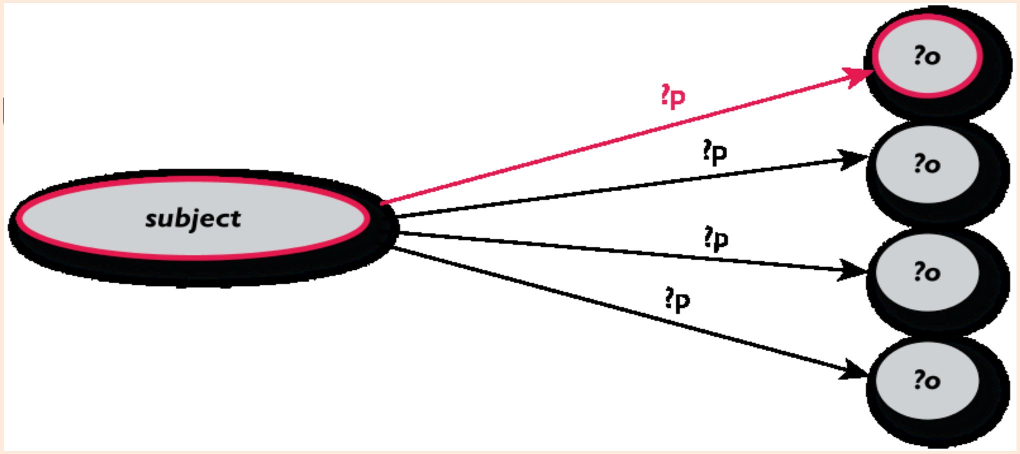
```
<rdf:Description rdf:about="http://…/isbn/2020386682">
    <f:titre xml:lang="fr">Le palais des mirroirs</f:titre>
    <f:original rdf:resource="http://…/isbn/000651409X"/>
</rdf:Description>
```

Querying RDF using SPARQL

- The fundamental idea: use graph patterns
- the pattern contains unbound symbols
- by binding the symbols, subgraphs of the RDF graph are selected
- if there is such a sele
the query returns bo
resources

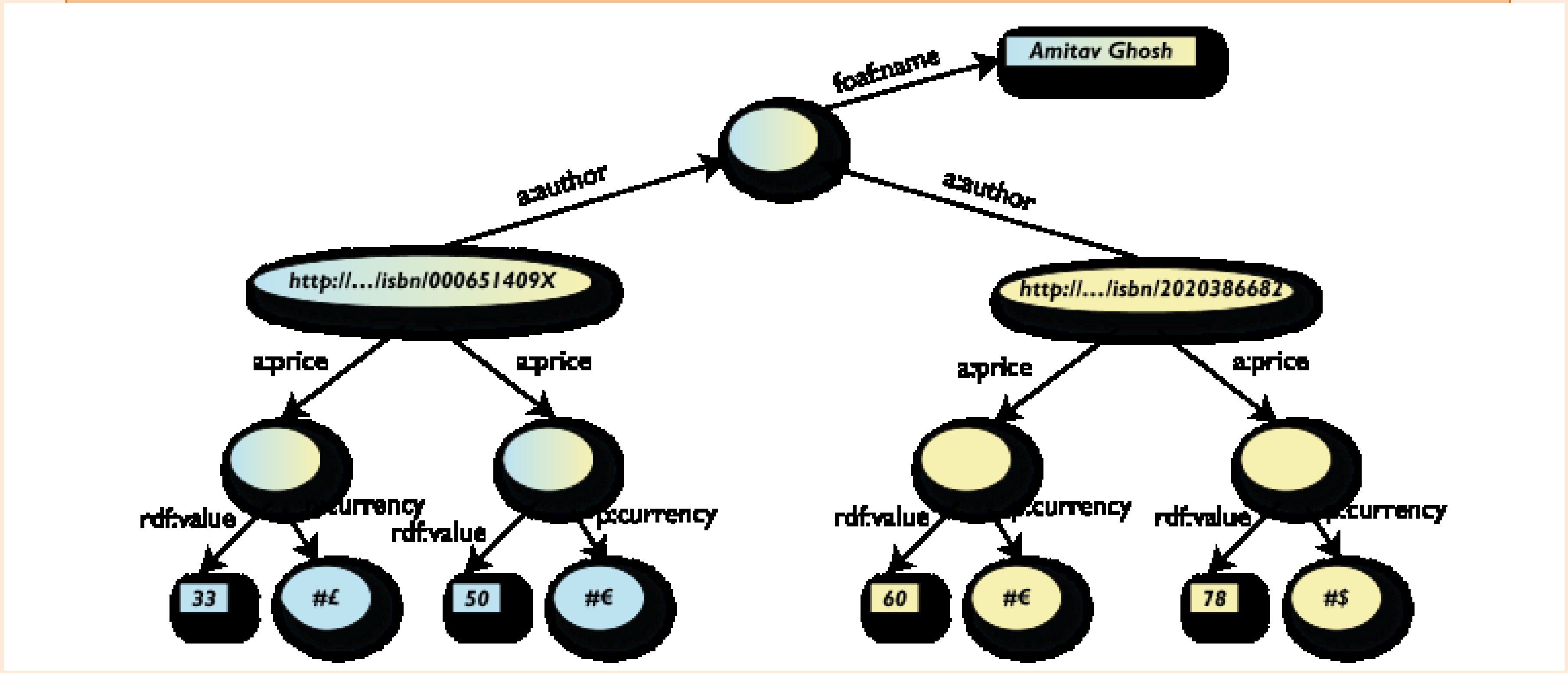
SELECT ?p ?o
WHERE {subject ?p ?o}

Where-clause defines graph patterns. ?p and ?o denote "unbound" symbols



Example: SPARQL

```
SELECT ?isbn ?price ?currency   # note: not ?x!
WHERE {?isbn a:price ?x.
       ?x rdf:value ?price.
       ?x p:currency ?currency.}
```



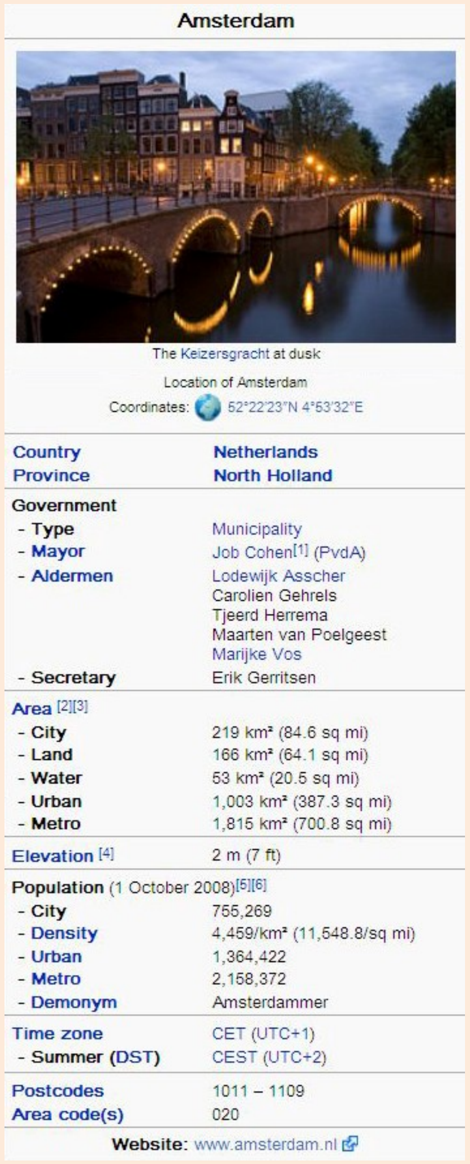
Linking Open Data

- Goal: “expose” open datasets in RDF
  - Set RDF links among the data items from different datasets
  - Set up, if possible, query endpoints
- Example: DBpedia is a community effort to
  - extract structured (“infobox”) information from Wikipedia
  - provide a query endpoint to the dataset
  - interlink the DBpedia dataset with other datasets on the Web

DBPedia

```
@prefix dbpedia
<http://dbpedia.org/resource/>.
@prefix dbterm
<http://dbpedia.org/property/>.

dbpedia:Amsterdam
  dbterm:officialName "Amsterdam" ;
  dbterm:longd "4” ;
  dbterm:longm "53" ;
  dbterm:longs "32” ;
  dbterm:leaderName dbpedia:Job_Cohen ;
  ...
  dbterm:areaTotalKm "219" ;
  ...
dbpedia:ABN_AMRO
  dbterm:location dbpedia:Amsterdam ;
  ...
```



Amsterdam

The Keizersgracht at dusk

Location of Amsterdam

Coordinates: 52°22′23″N 4°53′32″E

Country	Netherlands
Province	North Holland
Government	
- Type	Municipality
- Mayor	Job Cohen[1] (PvdA)
- Aldermen	Lodewijk Asscher Carolien Gehrels Tjeerd Herrema Maarten van Poelgeest Marijke Vos
- Secretary	Erik Gerritsen
Area [2][3]	
- City	219 km² (84.6 sq mi)
- Land	166 km² (64.1 sq mi)
- Water	53 km² (20.5 sq mi)
- Urban	1,003 km² (387.3 sq mi)
- Metro	1,815 km² (700.8 sq mi)
Elevation [4]	2 m (7 ft)
Population (1 October 2008)[5][6]	
- City	755,269
- Density	4,459/km² (11,548.8/sq mi)
- Urban	1,364,422
- Metro	2,158,372
- Demonym	Amsterdammer
Time zone	CET (UTC+1)
- Summer (DST)	CEST (UTC+2)
Postcodes	1011 – 1109
Area code(s)	020

Website: www.amsterdam.nl

Linking the Data

```
<http://dbpedia.org/resource/Amsterdam>
  owl:sameAs <http://rdf.freebase.com/ns/...> ;
  owl:sameAs <http://sws.geonames.org/2759793> ;
  ...
```

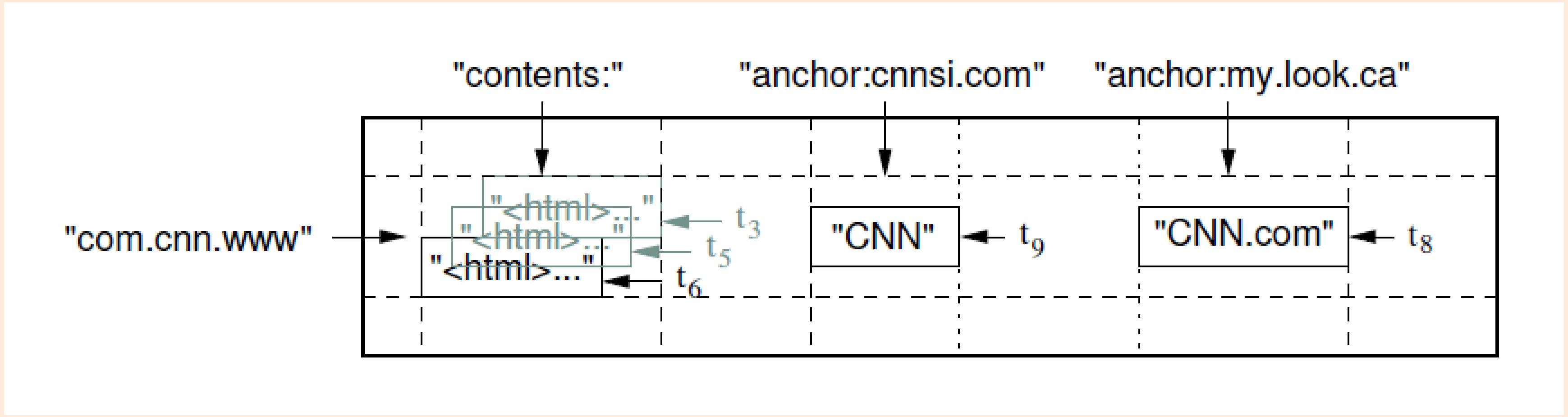
```
<http://sws.geonames.org/2759793>
  owl:sameAs <http://dbpedia.org/resource/Amsterdam>
  wgs84_pos:lat "52.3666667" ;
  wgs84_pos:long "4.8833333";
  geo:inCountry <http://www.geonames.org/countries/#NL>
;
 ...
```

Google's Bigtable

"*Bigtable is a sparse, distributed, persistent multidimensional sorted map*"

- It is a type key-value store:
  - Key: (row key, column key, timestamp)
  - Value: uninterpreted array of bytes
- Read & write for data associated with a row key is atomic
- Data ordered by row key and range partition into "tablets"
- Column keys are organized into column families:
  - A column key then is specified using <family:qualifier>
- Timestamp is a 64 bit integer timestamp in microseconds

Example: Webpages using Bigtable



- Row key = reversed string of a webpage's URL
- Column keys:
  - contents:
  - anchor:cnnsi.com
  - anchor:my.look.ca
- Timestamps: t3, t5, t6, t8, t9

CouchDB

- A distributed document database server
  - Accessible via a RESTful JSON API.
  - Ad-hoc and schema-free
  - robust, incremental replication
  - Query-able and index-able
- A couchDB document is a set of key-value pairs
  - Each document has a unique ID
  - Keys: strings
  - Values: strings, numbers, dates, or even ordered lists and associative maps

Example: couchDB Document

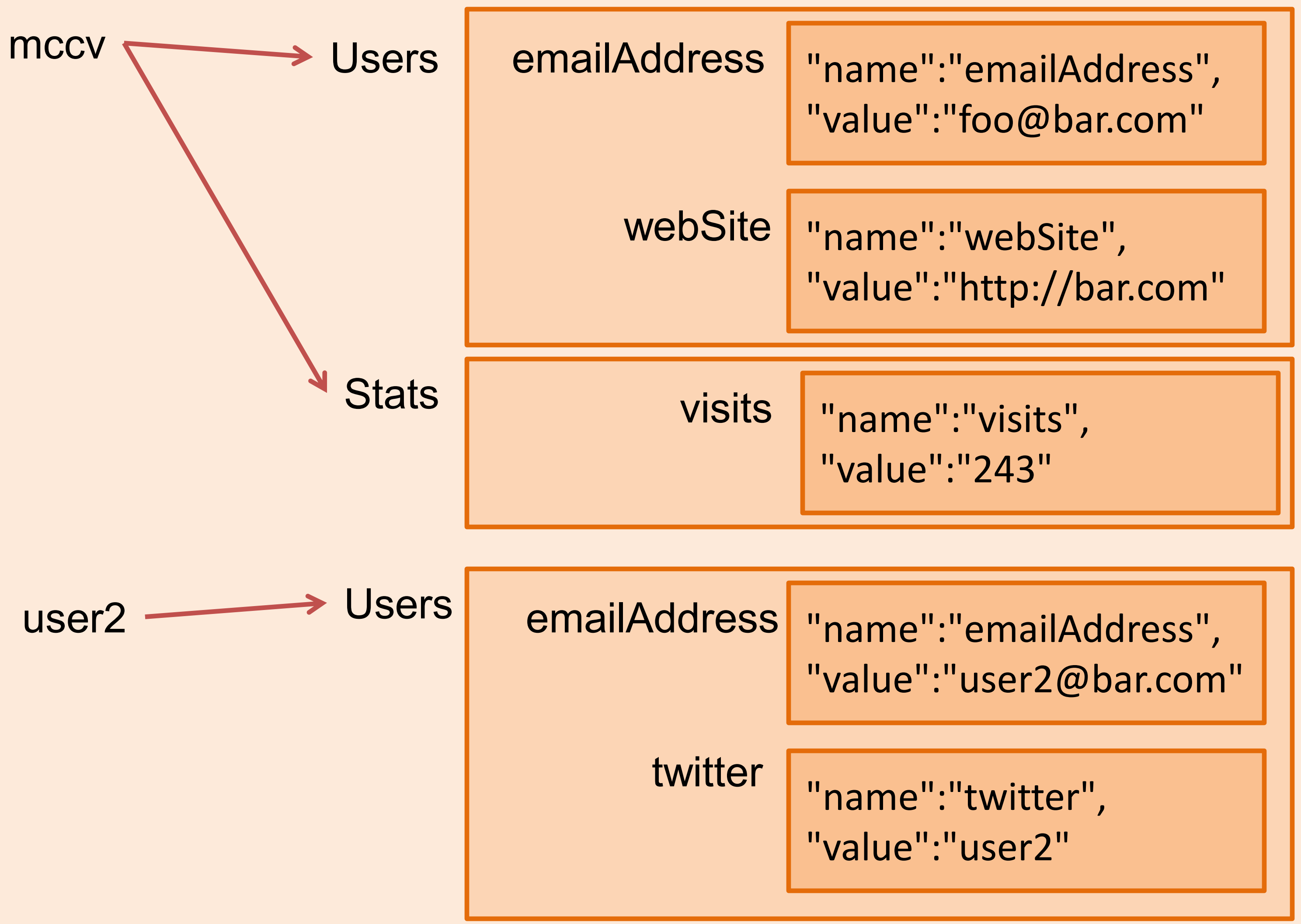
```
"Subject": "I like Plankton"
"Author": "Rusty"
"PostedDate": "5/23/2006"
"Tags": ["plankton", "baseball", "decisions"]
"Body": "I decided today that I don't like baseball. I like plankton."
```

- CouchDB enables views to be defined on the documents.
  - Views retain the same document schema
  - Views can be materialized or computed on the fly
  - Views need to be programmed in javascript

Cassandra

- Another distributed, fault tolerant, persistent key-value store
- Hierarchical key-value pairs (like hash/maps in perl/python)
  - Basic unit of data stored in a "column":
    (Name, Value, Timestamp)
- A column family is a map of columns: a set of name:column pairs. "Super" column families allow nesting of column families
- A row key is associated with a set of column families and is the unit of atomicity (like bigtable).
- No explicit indexing support – need to think about sort order carefully!

Example: Cassandra


mccv
Users
emailAddress
"name":"emailAddress",
"value":"foo@bar.com"
webSite
"name":"webSite",
"value":"http://bar.com"
Stats
visits
"name":"visits",
"value":"243"
user2
Users
emailAddress
"name":"emailAddress",
"value":"user2@bar.com"
twitter
"name":"twitter",
"value":"user2"